Appendix G

Evaporation Tools

Overall Function: This appendix describes the tools that should be provided in DDAP to compute estimates of evaporation to use for model calibration and performing certain water balance computations.

PETA Selection: When the Evaporation category is chosen, the user should first be given a list of PETAs that exist for the Basin. The user will then choose the appropriate PETA. How the tools are applied will also depend on whether the HPOR is being analyzed or whether the record is being extended, thus the user will also need to select the period to be worked on from a list of available periods defined for the chosen PETA.

Basic Display: Once the PETA and the period of record have been selected, the basic display for the Evaporation tools window should contain the following in addition to overlay, zoom, query, and units features:

- Basin boundaries - i.e. the overall boundaries of the Basin currently selected as specified in the Basin definition, and

- All stations with historical evaporation data - stations with pan evaporation measurements and those with the meteorological data needed to compute Potential Evaporation (PE) (should differentiate between type of data) - stations for which daily or monthly estimates of PE have been computed using the Compute Point PE tool should be highlighted.

Menus: Control and Tools menus should be included. The Control menu only needs a Quit option. The tools menu should contain the following options:

- Compute Point PE,
- Compute MAPE,
- PE versus Elevation ,
- Seasonal PE Adjustment Curve,
- ET Demand versus Elevation, and
- Estimate Areal ET Demand.

The capabilities that should be included for each of the Evaporation tools are described in this appendix starting on separate pages.

Compute Point PE

Function: To compute actual daily or average monthly point estimates of PE. There are two options under this tool. They are to compute daily time series from meteorological measurements and compute average monthly values from meteorological data or pan measurements. Each will be described separately.

Compute Daily PE Time Series

Function: To compute actual daily time series of PE based on meteorological measurements. This tool is intended to replace the computations currently included in the SYNTRAN program for computing daily PE for selected synoptic stations. Data sources other than those used by SYNTRAN, such as percent sunshine and direct observations of solar radiation, should be included.

Input:

- User selects station from those with historical meteorological data,
- Indicator as to whether the results should be adjusted to match the Technical Report #33 average annual values - only when PE computed for the HPOR,
- Meteorological measurements entered via the Enhanced Calibration data acquisition component (air temperature, dew point, wind speed, and solar radiation - or other values needed to estimate these quantities), and
- Period of record for computations (for the HPOR, the default is the period with historical data for the station within the HPOR - for an extension, the default is the period with historical data for the station within the selected extension period).

Method:

- Obtain average daily values of air temperature, dew point, wind travel, and solar radiation from available data,
- Compute daily PE values using appropriate equations (if any of the meteorological data are missing for the day, set the daily PE to missing), and
- Adjust values, if specified, so that the average annual value from the time series is the same as the average annual FWS evaporation for the location from map 3 of Technical Report #33 (adjustment computed and applied for the HPOR - for an extension period, the adjustment determined for the HPOR is used).

Displays Generated:

- Tabular summary for the current computational period similar to that produced by the current SYNTRAN program showing average PE for each month and year and long term averages on a monthly and annual basis (also adjustment factor, if applied), and
- Plot of accumulated PE versus time (use entire time series period that currently exists) - show average slope.

Output:

• Computed PE time series values - replace or append to existing PE time series for the station if one already exists, and
• If the HPOR, the adjustment factor applied or indicator that an adjustment was not selected.

Compute Average Monthly PE

Function: To compute average monthly values of PE for stations with meteorological data or pan measurements for the HPOR.

Input:
• User selects station from those with historical evaporation data available via the historical data acquisition component of the Enhanced Calibration System (station should have a daily PE time series generated by the Compute Daily PE Time Series option of this tool or pan measurements for at least a portion of the current period), or
• If a HPOR run, the user can define a new PE station (identifier and location) and manually enters available average monthly values (e.g. pan evaporation from Technical Report #34 based on meteorological computations or pan measurements - values could also come from other publications and be in the form of pan evaporation or PE) - these will be assumed to be appropriate for the HPOR,
• If an extension period, identifier of base station (must be a station that has daily PE time series or pan measurements, average monthly values defined for the HPOR, and an overlapping period of record with the station being processed),
• If the station has daily data, the period of record to analyze - if a HPOR run, the period should all be within the HPOR - if an extension run, the period can start prior to the extension period, but not extend beyond it (the station should have historical data for the entire run period),
• Indicator as to whether the final values should be adjusted to conform to map 3 in Technical Report #33, and
• Nearby stations, for which this option has been applied to compute average monthly PE, for use in comparing results and estimating missing months.

Method:
• If the HPOR,
  ◦ If existing average monthly values (computed from daily data or input monthly averages) are pan evaporation, multiply the values by the appropriate pan coefficient for the location obtained from map 4 of Technical Report #33,
  ◦ Estimate any missing winter months using the ratio of May-October to annual FWS evaporation obtained from Technical Report #33 and the actual May-October total for the station to get the November-April total - then prorate the winter total into monthly values using existing data for any of those months, nearby stations with winter PE estimates, and/or a user supplied distribution,
  ◦ Allow user to manually change any generated monthly average value, and
  ◦ If adjustment indicator is on, adjust the annual PE computed from the monthly

values to be the same as the annual FWS evaporation from map 3 of Technical Report #33,

- If an extension period,
  - If station has average monthly PE values already defined for the HPOR, tell user and no further computations are needed,
  - Compute monthly ratio of daily values for the selected station to the base station - for months with missing data, use the average ratio for the months with data,
  - Multiply the ratio to the base station by the HPOR average monthly PE for the base station to get the average monthly PE for the HPOR for the selected station,
  - Allow user to manually change any generated monthly average value, and
  - If adjustment indicator is on, adjust the annual PE computed from the monthly values to be the same as the annual FWS evaporation from map 3 of Technical Report #33,

Displays Generated:

- Plot of average values for each month on a calendar year basis - plot would start with values based on existing data and then change as pan coefficients are applied, winter values are generated, and changes made, and
- Plot of average monthly PE values on a calendar year basis for nearby stations selected by the user to assist in comparing results or determining missing winter months - these are stations for which the Compute Average Monthly PE option has already been applied.

Output: Computed average monthly PE values for the HPOR.

Compute MAPE

Function: To compute daily Mean Areal PE (MAPE) time series for individual Watersheds and also for zones within a subdivided Watershed from daily evaporation estimates and pan measurements at point locations.

Input: (all from previously stored information)

- List of Stations used during prior applications of this tool - also daily data (daily PE or pan measurements), meta data, and existing consistency corrections and F_e factors for all stations,
- Mean monthly PE values for each station for the HPOR as determined by the Compute Average Monthly PE option of the Compute Point PE tool, and
- If automatic station weighing is to be used (i.e. grid point weights), a boundary definition for each MAPE area included.

User Specification:

- List of Stations to be included (eligible stations are those for which the Compute Daily PE Time Series option of the Compute Point PE tool has been run and those with historical daily pan measurements) - if a HPOR run, all stations are user specified - if an extension period, only additional stations are user input (i.e. stations with data during the extension period that were not used during the HPOR) - also F_e factors for all new stations,
- Pan coefficient (input as initial consistency correction that applies to the entire period) for each station with pan measurements - input when stations are first specified,
- Indicator as to whether station consistency is to be checked or MAPE values are to be computed,
- If consistency is being checked, an indicator as to whether the checks should be on an annual or seasonal basis and if seasonal, the beginning month of winter and summer - also specification of how the stations are to be grouped on the double mass plots (currently a max of 5 stations per plot) - values are input by the user when the Compute MAP tool is first applied to the Basin and selected PETA, after that the values can be modified if the HPOR is being analyzed, but if the definition of the seasons for which consistency corrections are applied are changed, all currently defined seasonal corrections should be removed,
- If consistency is being checked and this is an extension period, the beginning date of the period to be run (can be prior to or equal to the start of the extension period),
- If MAPE values are being computed, the watersheds to be included (user chooses from a list of all watersheds defined - list shows whether time series already exist for each watershed for the period selected) - if a watershed is subdivided, MAPE values are automatically computed for all zones,
- If MAPE values are being computed and the HPOR chosen, the type of station weights to use for all watersheds selected (grid point or predetermined weights) - if an extension period, the station weighing method will be the same as used for the HPOR,
    - if grid point weights selected, boundary values must be available for all Watersheds and zones included (boundaries should be available for travel time zones but not for elevation zones), and
    - if predetermined weights selected, the user inputs list of stations and their weights for

each Watershed or zone.

Method: In general the basic procedure is incorporated in the current historical data MAPE program, however, some changes will be needed to that program when it is incorporated into DDAP. Some of the options to include when the program is incorporated into DDAP are:

- In all cases (i.e. whether consistency being checked or MAPE computed),
  - Observation time changes defined in the meta data file for each station are used when reading daily precipitation values,
- If station consistency is being checked,
  - If the HPOR - data are checked using IDMA type displays and interactive input of corrections,
  - If an extension period - IDMA method used but corrections can only be entered for the extension period,
- If MAPE values are being computed,
  - Computational period corresponds to the period chosen (i.e. HPOR or extension),

Displays Generated:

- Tabulation similar to that in the current historical data MAPE program showing for each MAPE area the monthly, yearly, and mean annual values, and
- Plot showing the accumulation of MAPE values versus time for all areas.

Output:

- MAPE time series for the selected period for all specified Watersheds (time series for extension periods are appended to the existing time series for each Watershed),
- Update list that indicates for which Watersheds and periods of record MAPE time series exist,
- If the HPOR,
  - Type of station weights used to compute MAP for each time series generated,
- If consistency is being checked, values defining whether the checks and any corrections are seasonal or annual and if seasonal, the beginning months of winter and summer, and how the stations are to be grouped on the consistency plots, and
- Any new values and updates to consistency corrections, F_e factors, and how stations are grouped on consistency check plots.

PE versus Elevation

Function: To define the annual PE versus elevation relationship for the Basin for the HPOR.

Input:

- Stations to include for which average monthly PE values are available from the Compute Average Monthly PE option under the Compute Point PE tool described in this appendix, and
- Other stations to be included based on published information - identifier, location, elevation, and annual PE.

Method and Display:

- Compute annual PE from average monthly values for stations with these data,
- Plot annual PE versus elevation in the form of Fig. 6-5-4 in the Calibration Manual,
- Delete and add stations as necessary, and
- Define relationship between annual PE and elevation for the Basin.

Output: Annual PE versus elevation relationship for the Basin.

Seasonal PE Adjustment Curve

Function: To define seasonal PE adjustment curves for Watersheds and zones within subdivided Watersheds that apply for the HPOR. This tool is only valid for the HPOR.

Input:

- User selection of a Watershed, and
- Indicator as to how initial seasonal PE adjustments are to be defined,
  - Based on NDVI green fractions (NDVI data must be available),
  - Based on method described in the FAO Irrigation and Drainage paper 24 by Boorenbos and Pruitt (complete reference in Calibration Manual) - values required could be input by the user based on provided guidelines and defaults based on vegetation cover ,
  - Based on values for another Watershed or zone (values must be defined for that area), or
  - User specified values.

Method and Displays:

- Generate display showing all existing seasonal PE adjustment curves for the Basin and specified PETA,
- Display initial definition of the seasonal PE adjustments for the selected Watershed (if multiple zones show all zones) - also include prior seasonal adjustment curve, if available, and
- Allow user to change values.

Output: Seasonal PE adjustment curve for the Watershed or each zone within a subdivided Watershed (overwrite previously defined curves).

ET Demand versus Elevation

Function: To define an annual ET Demand versus Elevation relationship for the Basin for the HPOR. This tool only valid for the HPOR.

Input:

- Plot of annual actual ET versus elevation developed using the Water Balance Summary tool described in Appendix D,
- Annual PE versus elevation relationship for the Basin derived using the PE versus Elevation tool described in this appendix (optional), and
- User specified relationship indicating how the ratio of actual ET over ET Demand varies with elevation (relationship can be modified during subsequent uses of this tool).

Method and Display:

- Start with plot of annual actual ET versus elevation,
- Add annual PE versus elevation relationship to the plot, if available,
- User defines annual actual ET versus elevation relationship,
- Apply the relationship indicating how the ratio of actual ET over ET Demand varies with elevation to the relationship of how annual actual ET varies with elevation to produce the relationship between annual ET Demand and elevation for the Basin.

Output: ET Demand versus elevation relationship for the Basin (only one such relationship for a given Basin and PETA).

Estimate Areal ET Demand

Function: To generate mean monthly ET Demand values for use in model calibration for Watersheds and zones within subdivided Watersheds for the HPOR. This tool is only valid for the HPOR. There are two options within this tool. They are ET Demand from PE and ET Demand from Elevation. Each is described separately.

ET Demand from PE

Function: To produce mean monthly ET Demand values from point and areal PE estimates.

Input:

- User selection of a Watershed (for subdivided Watersheds, ET Demand values will be generated for all zones),
- Indicator of whether PE is to be obtained from point or areal estimates,
- If PE from point estimates,
  - User specification of stations to use and weights assigned to each station for each area - stations are those for which monthly PE estimates have been generated using the Compute Average Monthly PE option of the Compute Point PE tool described in this appendix,
  - Area average annual PE for the Watershed or each zone from:
    - Annual FWS evaporation from map 3 of Technical Report #33, or
    - PE versus Elevation tool described in this appendix using the mean elevation of the Watershed or zone.
- If PE from areal estimates, digitized data from NOAA Technical Reports #33 and #34 that are used by the current version of CAP (annual FWS evaporation, seasonal FWS evaporation, annual amplitude of FWS evaporation, and phase angle of the seasonal cycle of FWS evaporation), and
- Seasonal PE adjustment curve for the Watershed or each zone as defined by the Seasonal PE Adjustment Curve tool described in this appendix.

Method and Displays: Two alternatives should be provided. The first would be used to initially define the mean ET Demand values and could be used to generate new values if either PE or the seasonal PE adjustment curve were modified. The second could be used to directly modify the ET Demand values and produce a modified seasonal PE adjustment curve.

- Define monthly ET Demand:
  - If PE obtained from point estimates,
    - Compute areal average monthly PE values by summing the monthly values for each station times the station's weight and then adjusting the resulting monthly values so that the annual PE is the same as the specified areal annual PE, and
    - Multiply the average monthly areal PE values by the specified seasonal PE adjustment curve to obtain mean monthly ET Demand estimates.

◦ If PE obtained from areal estimates,
· Generate monthly PE values for each area from the digitized data derived from Technical Reports #33 and #34, and
· Multiply the average monthly areal PE values by the specified seasonal PE adjustment curve to obtain mean monthly ET Demand estimates.

• Modify ET Demand:
◦ User changes ET Demand values for one or more months,
◦ New seasonal PE adjustment curve is generated by dividing the ET Demand for each month by the areal average PE for the month, and
◦ User judges whether the new seasonal PE adjustment is reasonable - if not, the first two steps are repeated.

Output:
• Mean monthly ET Demand values for the Watershed and each zone if a subdivided Watershed, and
• Revised seasonal PE adjustment curve if the curve for a Watershed or zone is modified.

ET Demand from Elevation

Function: To produce mean monthly ET Demand values based on the ET Demand versus elevation relationship for the Basin.

Input:
• User selection of a Watershed (for subdivided Watersheds, ET Demand values will be generated for all zones),
• Annual ET Demand versus elevation relationship for the Basin as defined by the ET Demand versus Elevation tool described in this appendix,
• Annual PE versus elevation relationship for the Basin as defined by the PE versus Elevation tool described in this appendix,
• Seasonal PE adjustment curve for the Watershed or each zone as defined by the Seasonal PE Adjustment Curve tool described in this appendix, and
• Information to convert annual PE to monthly PE:
◦ One station per Watershed or zone (stations must have mean monthly PE values defined using the Compute Average Monthly PE option of the Compute Point PE tool described in this appendix), or
◦ Digitized data sets from Technical Reports #33 and #34 described under the ET Demand from PE input section for this tool.

Method and Displays:
• Get the annual ET Demand for the Watershed or each zone from the mean elevation of the area and the annual ET Demand versus elevation relationship,
• Get the annual PE for each area from the mean elevation of the area and the annual PE versus elevation relationship,
• Determine mean monthly PE for each area by prorating the annual PE using either the

specified station or the Technical Report #33 and #34 digitized values,

- Generate mean monthly ET Demand for each area:
  - Multiply the areal average PE for each month by the current PE adjustment for the month,
  - Adjust the result to produce the annual ET Demand obtained from the mean elevation,
  - Show seasonal curves (monthly values) of areal average PE, mean ET Demand, and PE adjustment (mean ET Demand divided by areal average PE) , and
  - User can change the seasonal shape of the mean ET Demand interactively by changing the shape of either the monthly PE curve (annual PE remains the same), the seasonal PE adjustment curve, or the monthly ET Demand values (seasonal PE adjustment curve is altered as monthly ET Demand values are changed) - in all cases the annual ET Demand must remain the same.

Output: Mean monthly ET Demand and updated seasonal PE adjustment curves for the Watershed and each zone within subdivided Watersheds.